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DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
JOSEPH A. HOLMES, DIRECTOR

PROPOSED REGULATIONS FOR THE

DRILLING OF GAS AND OIL WELLS

WITH COMMENTS THEREON

BY

O. P. HOOD AND A. G. HEGGEM

WASHINGTON
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PROPOSED REGULATIONS FOR THE DRILLING OF GAS AND OIL WELLS, WITH COMMENTS THEREON.

By O. P. Hood and A. G. Heggem.

INTRODUCTION.

The Bureau of Mines has been asked by various State officers and individuals for suggestions and opinions regarding problems of safety involved in the interrelation of gas and oil wells and coal mines. No standard practice has been developed detailing the design and construction of wells through coal beds that are being mined or that may soon be mined, nor has there always been general agreement as to just what dangers should be avoided. Reasonable uniformity in legislation in the several States as to the manner of treating the fundamental problems is desirable.

That there might be available such information as should lead to greater safety the Director of the Bureau of Mines arranged conferences of the several interests. Separate conferences with men representing the coal mines, the gas wells, and the oil wells, and with State geologists, led to a general conference February 7 and 8, 1913. At this conference representatives of the Bureau of Mines presented a general discussion of the problem, including illustrations of mine troubles due to the proximity of gas and oil wells to mines, and tentative suggestions for legal regulation of bore holes passing through workable beds of coal. The proceedings of this conference have been published in Bulletin 65 of the Bureau of Mines.[a]

The tentative regulations proposed by the bureau were referred to a committee of 20. This was composed of 3 members from each of the following interests: Coal, natural gas, petroleum, State geologists, State mine inspectors, and the Bureau of Mines. To these 18 were added the president and the secretary of the conference. This committee met March 1 and March 10, and presented a revised report to the general conference which was called together March 11. A general invitation was issued to all persons interested to attend the final general conference, at which the attendance, though not large, was representative and evinced active interest. The proposed regulations drafted by this conference are in the form of an outline of

[a] Oil and gas wells through workable coal beds, papers and discussions, by G. S. Rice, O. P. Hood, and others. 1913. 101 pp., 1 pl., 11 figs.

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desirable legislation. The outline may be developed in legal form in each State to meet the needs of the several industries affected and the differing forms of State control.

Following the outline are presented comments that give the results of the general discussion and the reasons for some of the suggestions in the outlined legislation.

The conference did not attempt to draft the outline in legal form and phraseology. However, the intent and meaning of the conference is sufficiently set forth to form the basis for a more formal expression.

DRAFT OF REGULATIONS.

The draft of the proposed regulations follows:

REGULATIONS To provide for the location, drilling, casing, protecting, operating, abandoning, plugging, and filling of natural-gas and petroleum wells, and for the protection and preservation of life and property, especially in and about coal mines in gas and oil regions, creating the office of chief inspector of natural-gas and petroleum wells, and providing penalties for the violation of these regulations.

ARTICLE I.

Definitions.

SECTION 1. For the purposes of these regulations the definitions of the terms contained herein shall be as follows:

Well.—A bore hole drilled for the purpose of developing natural gas or petroleum, or a bore hole producing natural gas or petroleum.

Well operator.—Any person, persons, firm, partnership, corporation, company, or association, that drills, operates or abandons, or purposes to drill, operate, or abandon such well as hereinbefore defined.

Coal operator.—Any person, persons, firm, partnership, corporation, company, or association owning, leasing, or operating coal mines, or coal properties, not including coal-stripping operations.

Plat.—A map, drawing, or print, made in accordance with the provisions of these regulations, as hereinafter contained.

Casing.—The pipe commonly used within wells drilled for natural gas and petroleum. The sizes of casing refer to nominal commercial dimensions.

Cement mortar.—Cement mortar shall consist of one part of Portland cement and two parts of clean sand, mixed with sufficient water.

Coal bed.—A workable bed or seam of coal that may be mined during the reasonable life of a well proposed to be drilled through it.

Well inspector.—The chief inspector of natural-gas and petroleum wells, or his duly authorized deputy.

ARTICLE II.

Location of Well.

SECTION 1. When a location for a well has been made, the well operator shall make application in writing to the chief well inspector for a license to drill, and shall send therewith a description and plat in duplicate of the proposed location.

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Survey.

SEC. 2. The location shall be determined by survey, and the description and plat shall give the courses and distances from two permanent points on the boundaries of the tract of land on which the proposed well is to be located, together with the name of the tract of land, names of adjoining tracts, township or district, and county.

Copies of plat.

SEC. 3. The well operator shall send to the coal operator, if known, and to the State coal-mine inspector, a copy of the description and plat filed with the chief well inspector.

Verification of location.

SEC. 4. Immediately on receipt of the plat the coal operator shall verify the well location and mail to the well operator a plat showing the present and proposed mine workings under the tract of land on which the proposed well is to be located.

Time limit of complaint.

SEC. 5. The license to drill shall issue immediately on the expiration of 5 days (excluding legal holidays) after the application and the plat of location have been received by the well inspector, unless he makes complaint or shall have received notice of complaint during that time.

Time limit for issue of license.

SEC. 6. If notice of complaint is made by or served on the well inspector within the said 5 days, then it shall be the duty of the well inspector to confer with the several interests, including the State mine inspector, the coal operator, the well operator, and, where possible, the owner of the land and the owner of the royalty interest, and designate, within 10 days of the receipt of the application for license, a suitable location for the well, or, if no well can be drilled on the premises because of conditions hereinafter specified, refuse to issue a license to drill.

Resurvey.

SEC. 7. If the well is relocated, a resurvey shall be made by the well operator, and a corrected description and plat shall be mailed as previously required.

Mine plats.

SEC. 8. Each coal operator shall furnish annually to the well inspector a plat of all of his present and immediately projected mining operations within the State, showing the location of all known wells. The coal operator shall also, if so requested, furnish to any well operator a plat of the mine under the property leased, owned, or operated by the said well operator.

Distance of well from buildings, etc.

SEC. 9. No well shall be located within three hundred (300) feet of a hoisting or air shaft, slope, or drift into an artificially ventilated coal mine that has not been definitely abandoned or sealed, nor shall such well be located within three hundred (300) feet of any mine shaft house, boiler house, engine house, power house, mine fan, or mine tipple, unless such structure has been abandoned.

Distance of well from mine ways.

SEC. 10. No well shall be drilled within fifteen (15) feet of any underground haulage way, traveling way, drainage way, or airway.

Issue of license.

SEC. 11. It shall be the duty of the chief well inspector to issue the license in duplicate, and the well operator shall display at the location one copy of the license properly protected from injury, and in such place and manner that it may be easily seen.

Expiration of license.

SEC. 12. The license shall expire at the end of one year from the date of issue unless drilling operations are actually in progress.

ARTICLE III.

MANNER OF DRILLING AND PROTECTING WELL.

SECTION 1. Each well passing through a workable bed of coal shall be drilled, cased, and protected in the manner hereinafter provided:

(*a*) *Where the coal is in place.*—A hole of a diameter six (6) inches greater than the inside diameter of the outside casing to be put through

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the coal shall be drilled at least thirty (30) feet below the bottom of said coal bed. Within this hole shall be placed the casing, and the space between the outside of said casing and the wall of the hole shall be filled with cement mortar, or puddled clay, to a height of at least thirty (30) feet above the top of said coal bed, to exclude water from the coal bed.

(*b*) *Where the coal has been removed and the mine excavation is inaccessible.*—A hole of a diameter sufficiently large to permit the insertion of a liner four (4) inches larger in diameter than the inside diameter of the casing to be put through the coal shall be drilled at least thirty (30) feet below the bottom of said coal bed. Within this hole shall be placed a liner four (4) inches larger than the inside diameter of the said casing and extending from the bottom of said hole to at least thirty (30) feet above the mine roof. A string of casing centrally guided by shoes or winged guides shall be placed within the said liner and the space between the liner and the casing shall be filled with cement mortar or puddled clay to the top of the liner. To exclude water, the space between the said casing and the wall of the hole and immediately above the top of the liner shall be filled a distance of at least ten (10) feet with cement mortar or puddled clay.

(*c*) *Where the coal has been removed and the mine excavation is accessible.*—The method may be as provided in either paragraph *a* or paragraph *b* of this section, provided that if the method prescribed in paragraph *a* be chosen the well operator shall at his own expense provide a suitable retaining wall laid in cement mortar to retain the cement mortar or puddled clay about the casing. Said wall shall extend from two (2) feet below the mine floor to the roof of the mine, and shall be of such size as to retain at least two (2) inches of puddled clay or cement mortar about the said casing.

Affidavit as to casing.

SEC. 2. The well operator, on completion of the work of casing through a coal bed, shall make an affidavit, signed by two men having at least three years' experience in casing wells, as to the method of casing and protecting the well, said affidavit to be filed with the chief well inspector.

Vent.

SEC. 3. Under any of the above provisions the work of casing and protecting from gas and water through the coal bed shall be completed before the well is drilled to a greater depth; and in the event of any well being productive of oil or gas, the space between the said outside casing and the next string of such other casing as may be left in shall remain open, the top being provided with a suitable device to permit ventilation and at the same time to prevent dirt or débris from falling in, or being thrown in, or the ventilating opening from being readily closed.

ARTICLE IV.

ABANDONMENT OF WELL.

Notice.

SECTION 1. The well operator, when he purposes to abandon any well, shall send a written notice of his intention to the chief well inspector, and the work of plugging the hole or pulling the casing shall not proceed until the well inspector shall be present to see that said plugging is done as prescribed by these regulations, except as hereinafter provided.

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Procedure in absence of inspector.

SEC. 2. In case the well inspector fails to be present within three days from receipt of notice, then the work may proceed, provided that two men who have had at least three years' experience in the plugging of wells are present and make affidavit in duplicate that the work was done in accordance with the provisions of these regulations, said affidavits to be filed with the chief well inspector and put on record in his office.

Copy of license.

SEC. 3. With the notice of abandonment the well operator shall send to the chief well inspector a legally certified copy of the license to drill, provided the well was drilled under the provisions of these regulations.

Locating old wells.

SEC. 4. If the well was drilled prior to the passage of these regulations, the well operator shall send to the chief well inspector with the notice of abandonment a description and plat, as described and platted in applications for license to drill, showing the location of the well.

Method of plugging.

SEC. 5. Every well, upon abandonment, must be plugged and filled solidly and tightly from the bottom to the top as follows:

The hole must be filled with rock sediment, sand, clay, or other suitable material from the bottom of the well to a hard and firm stratum below the last string of casing set in above the producing oil or gas sands. If a well inspector shall declare that it is impracticable to fill the cavity in the lowest producing sand, then he shall permit the well operator to place plugs at the top of the lowest producing sand and to fill as hereafter specified.

In the firm, hard stratum three seasoned wood plugs of a diameter equal to the diameter of the hole, and each of a length of at least three (3) feet shall be driven into place. Above the third plug ten (10) feet of clay must be placed and thoroughly tamped down so as to prevent the passage of oil, gas, or water.

Immediately below the seat of each and every string of casing there shall be driven a seasoned wood plug as described, and all spaces between wood plugs shall be filled solidly and tightly with rock sediment, clay, sand, or other suitable material as the casing is withdrawn length by length. All plugs shall be driven in place with proper drilling tools.

In the case of a well in which the outside casing has been cemented as herebefore prescribed, said outer casing may be cut off at a point not less than fifty (50) feet above the coal bed and removed, but in any event the hole shall be filled to the surface.

The locations of the plugs herein prescribed are designated with reference to the relative positions of the workable coal beds, and of the gas and oil sands, for the purpose of preventing the passage of oil or gas into the workable coal beds, and of water into the oil and gas sands; and if any well presents a variation in such relative positions of the said strata such additional wood plugs as the well inspector may deem necessary shall be driven into place by the well operator.

Report of plugging.

SEC. 6. When the work of plugging and filling from bottom to top shall have been completed, the well operator, or his authorized agent, shall make a report in duplicate to the chief well inspector, on forms to be furnished by the well inspector, showing the date of completion of the well, the depths to the coal beds, the names of and the depths to all productive oil or gas measures, the total depth of the well, and the

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location and kind of all plugs and filling used, and the method followed in placing the same.

SEC. 7. If the well inspector has been present during the performance of the work mentioned in section 6 of this article, he also shall sign the report to the chief well inspector.

SEC. 8. If the well inspector has not been present, the report mentioned in section 6 of this article shall be executed by two men employed on the work, as provided for in these regulations.

Protection of casing by coal operator.

SEC. 9. When the coal is removed from around a well casing or liner, the coal operator shall protect said casing or liner from corrosion and mechanical injury by a wall of material suitable to retain two (2) inches of cement mortar between the said wall and the said casing or liner; this protection shall extend from two (2) feet below the mine floor to the roof of the mine, except in the case of an abandoned well that has been plugged and filled as prescribed in these regulations.

ARTICLE V.

CHIEF INSPECTOR OF NATURAL-GAS AND PETROLEUM WELLS.

Office.

SECTION 1. There is hereby created the office of chief inspector of natural-gas and petroleum wells.

Appointment.

SEC. 2. A chief inspector of natural-gas and petroleum wells shall be appointed by the governor, or by a commission provided for the purpose, from an eligible list of men who have satisfactorily passed an examination establishing their technical and practical fitness for the position.

Salary.

SEC. 3. The salary and necessary travel expenses of the chief well inspector shall be borne by the State, which shall also maintain an office provided with suitable filing equipment.

Bond.

SEC. 4. The chief well inspector shall, before entering on the discharge of his duties, give bond in the sum of $————, with approved sureties, for the faithful discharge of his duties; and shall take oath that he will discharge his duties with impartiality and fidelity to the best of his knowledge and ability. But no person who is acting as manager or agent of any oil or gas company, or any coal company, or who is interested in operating any oil or gas well or any coal mine, shall at the same time act as chief well inspector under these regulations.

Assistants.

SEC. 5. The chief well inspector shall be authorized to appoint field and office assistants, whose salaries and expenses shall be borne by the State.

Appeal.

SEC. 6. An appeal from the decisions of any assistant may be made to the chief well inspector.

Duties.

SEC. 7. It shall be the duty of the chief well inspector to carry out all of the provisions of these regulations and to keep a complete record of, and to prepare for publication a yearly report of, the wells drilled in the State, together with their location, date of completion, depth, character of product, date of abandonment, name of owner, and other information.

The well inspector shall receive and investigate all complaints as to injury, present or impending, due to lack of precaution on the part of any well operator or coal operator. If he finds the complaints against the coal operator to be well founded, he shall lay the facts before the State mine inspector.

In case of failure of the well operator to plug an abandoned well in accordance with the provisions of these regulations, it shall be the duty

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of the well inspector to have the work performed by contract and to assess the cost against the well operator.

If the well inspector shall discover any well being drilled, operated, or plugged contrary to the requirements of these regulations, he shall order the workmen engaged upon such work to cease at once, and shall not permit the work to be resumed until he is satisfied that the law will be complied with.

The well inspector shall determine whether plats are sufficient for the purpose of accurately locating wells, and if, in connection with the location of any proposed well, the available plats and descriptions are unsatisfactory, he shall cause to be made such new survey as shall be necessary. The cost of said survey shall be borne by the applicant unless it shall be shown that the original plat is correct, in which case the cost of the new survey is to be borne by the State.

It shall be the duty of the chief well inspector to transmit to the proper county recorder the duplicate of plats, descriptions, applications, and reports sent to him by well operators, and these shall be recorded in a book kept specially for this purpose by the county recorder.

Right of entry.

SEC. 8. To enable the well inspector to perform the duties imposed upon him by these regulations, he shall have the right at all times to approach and examine any well in his district, and, with the authority of the State mine inspector, to enter any mine affected, and upon discovery of any violation of these regulations or upon being informed of such violation, he shall institute proceedings against the person or persons at fault, under the provisions of the law provided for such cases.

ARTICLE VI.

ENTRY OF MINE BY REPRESENTATIVE OF WELL OPERATOR.

SECTION 1. When a well is so located that it passes through a mine or near a mine, the well operator may appoint as his representative a mining engineer or other competent person experienced in mining operations, who shall with the written permission of the chief or district State mine inspector have the right to enter the mine at such times as will not interfere with the operation of the mine.

ARTICLE VII.

PENALTY FOR NONCOMPLIANCE.

SECTION 1. Any coal operator or well operator who neglects or refuses to comply with the provisions of these regulations, or who violates any of the provisions or requirements thereof, shall be deemed guilty of a misdemeanor, and shall, upon conviction thereof in the court of the county in which the misdemeanor was committed, be punished by a fine or imprisonment at the discretion of the court.

ARTICLE VIII.

INCONSISTENT ACTS REPEALED.

SECTION 1. All acts or parts of acts inconsistent herewith are hereby repealed.

SEC. 2. Each section of these regulations and every part thereof is hereby declared to be an independent section or part of a section, and if any section or subsection shall for any reason be held unconstitutional the validity of the remaining subsection and sections shall not be affected thereby.

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ESSENTIAL FEATURES OF REGULATIONS.

The essential features prescribed in the foregoing suggested regulations are:

(1) Accurate and formal location and recording of wells.

(2) Cooperation of the several parties interested to obtain a safe location.

(3) Designation of efficacious methods of casing and protecting wells through coal beds.

(4) Formal abandonment of wells.

(5) Safe methods of plugging wells.

(6) Adequate inspection.

INTENT OF VARIOUS PROVISIONS OF REGULATIONS.

WELLS.

Wells such as water wells, prospecting bore holes, and elevator wells, which may be drilled either within or outside of areas where coal, natural gas, or petroleum exists, do not come under the provisions of the regulations. Though it is believed that such wells in their drilling, operation, and abandonment may be a menace to other property, such as mineral and fresh waters, nevertheless the caring for such a large number of wells makes it desirable to omit for the present such wells in the inspection scheme. To limit the definition of a well to those bore holes exceeding a certain depth would be impracticable, because some producing wells are found at very shallow depths, in some cases even above relatively shallow coal measures. In hilly country a reasonable limitation as to depth would manifestly give a great advantage to locations in deep valleys as compared with locations on hillsides or hilltops without in any way changing the relationship of the gas-producing sand and the coal bed.

A limitation of diameter also seems impracticable, because small holes drilled to producing measures might be as much of a menace as larger holes.

Some objection to this definition of a well was urged in the conference because the definition may be held to include holes drilled for prospecting for coal, but it is evident that such holes are not included unless they produce natural gas or petroleum, and if they do so produce, they are manifestly a possible source of danger and should be ranked as any other producing well, and would hence come within the definition of "well" as here used and consequently would come under the provisions of the proposed regulations.

WELL OPERATOR.

By well operator is meant the nearest legally responsible party concerned in the well drilled or to be drilled.

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COAL OPERATOR.

By coal operator is meant the nearest legally responsible party concerned in the coal mine penetrated or to be penetrated.

PLAT.

It is the custom of large operators to have extensive maps showing the location of their operations, and in the designation of a new location tracings or reproductions of portions of the general map are available. It is manifestly convenient to have the plat that is required by the regulations of the same scale as the general map, and the chief well inspector should make such regulations as to scale and form of plat as will serve the purposes of the regulations and the convenience of the parties in the State interested.

CASING.

It will be to the interest of the well operator to provide a casing of suitable weight, dimension, and quality. It was not deemed desirable to prescribe in detail the materials for this purpose.

CEMENT MORTAR.

Complete specifications for suitable cement mortar would include much more than is here given, and such complete specifications for the best work should agree with the specifications of the American Society for Testing Materials. For field work, in which it is often impossible to obtain selected material, considerable leeway for the judgment of the inspector must be allowed.

COAL BED.

A proper definition of coal bed received a large amount of discussion and consideration in the conference. To frame such a definition as shall bring about the needed protection to workers in the mines, and at the same time shall not impose an undue hardship on the drilling of wells, is a difficult task, and such definition must be applied with a large measure of good judgment on the part of the responsible official. To protect by an expensive method a coal bed that will not be worked before such a well shall have been securely plugged and the formations returned as nearly as possible to their original condition is not the intent of the regulations. The workableness of any particular coal bed depends not only on its depth, its thickness, and its value, but on its location with respect to possible transportation facilities.

The length of life of any well that may be put through such a workable seam of coal is also a variable quantity and to estimate such a life would require a general knowledge of the field and the probabilities of production in that special locality. That these several variables

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can be anticipated by a rigid interpretation of law is extremely doubtful, and a large measure of discretion must be allowed in interpreting the intent of the regulations in this respect. It has been proposed that this discretion should be exercised by the State geologist, inasmuch as a knowledge of geological conditions is absolutely necessary in the problem. It has also been proposed that this interpretation and discretion should be exercised by a commission constituted of parties having information and interest in the matter. This discretion may be lodged entirely in the chief inspector prescribed by the regulations, or in the chief mine inspector, or the matter may be so left that in case of dispute a court may render a decision based on the testimony of all parties concerned.

LOCATION OF WELL.[a]

It was the very general opinion in conference that the matter of locating a well should be a formal one under such regulations as would make the location a matter of record that could in the future be available to any person. It was also the general opinion that so far as possible the several persons interested in the location of a well should mutually agree as to the location, and that having agreed the records of each interested person should be complete and definite. It was also generally agreed that the element of time is especially important in the business of well drilling and that all reasonable concession should be made by parties other than the well driller to expedite an agreement and the issue of a license to drill. The intent of the several sections was to permit drilling in as short a time as was feasible.

There was considerable discussion as to just how surveys should be made sufficiently accurate to permit the relocation of an old well, surface indications of which had disappeared. It seemed desirable to make such a survey with reference to section corners or United States Geological Survey monuments when these were available, but it was pointed out that in many localities permanent monuments of equal value were not to be had, and that the whole matter of boundary lines or corners of plats of ground might be in dispute and in process of legal adjustment. It was also pointed out that in opening a new field in which rapid work would perhaps be necessary, it would be a hardship to be obliged to settle definitely legal matters of boundary and survey, and that the purposes of accurate location could be obtained by allowing well operators to use permanent points on the boundaries of the tract of land on which the well should be located, provided there should be such permanent points. If such permanent points should not be available, it was suggested that

[a] Art. II.

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permanent monuments might be put up on such real or supposed boundaries by the well operator.

The surveying for this location should be of a high order and performed by engineers or surveyors of recognized standing and ability.

FILING OF DUPLICATE DESCRIPTIONS.[a]

In order that the coal operator shall have an opportunity to make objection to the proposed location, it is required that the well operator shall send to the coal operator a copy of the description and plat that is filed with the well inspector. In most cases the well operator and the coal operator would have been in correspondence on the matter before an application for license would be made. The duty of filing the description was placed on the well operator rather than on the chief well inspector in order to save time and make the five-day time limit more reasonable and also make more desirable a previous cooperation of the parties. For the same reason the well operator is required to notify the State coal-mine inspector so that he also may make objection within the time limit of five days.

VERIFICATION OF LOCATION.[b]

It is the present practice of organizations working in harmony to exchange plats, and the requirement of section 4 of Article II is only an expression of a current good practice.

The well operator, unless fully informed of present and immediately proposed mine workings, may not locate a well in an acceptable place although he may be perfectly willing to do so. In case the well operator is not at once supplied with such a plat of the mine workings, he may reasonably suppose that there is no objection to the location as proposed.

TIME LIMIT OF COMPLAINT.[c]

In the great majority of cases the license to drill can be expected to be issued at once, either because there is no possible complication with mine workings or other interests or, more likely, because the interested parties have previously conferred and come to an amicable agreement. If such previous agreement has not been arranged, then a period of five days is allowed for the well inspector, coal operator, and other interested parties to make formal objection, the lack of which requires the issue of the license at the end of five days. The five-day period in which to file objections seemed a short time to many of the conferees, and in order to insure full five days of mail service, legal holidays were excluded, and the five-day period was made to date from the receipt of the application by the well inspector. The drillers of wells, however, pointed out that many

[a] Art II, sec. 3. [b] Art. II, sec. 4. [c] Art. II, sec. 5.

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times the drilling operation was to be carried out under short-time leases, and that the delay of a day or two might be very important and was always a matter of considerable expense. In drilling near the line of the territory covered by a lease it is often of great importance that a well be completed in advance of competing drillers, and no unreasonable artificial obstruction to reasonable enterprise should be interposed. It was believed that the retaining of this seemingly short time would tend to bring about previous agreement on the part of all parties so that the whole matter would be laid before the well inspector at the time of application for the lease.

TIME LIMIT FOR ISSUE OF LICENSE.[a]

If the well inspector receives an objection from a coal operator, or if he is in doubt himself as to whether a proposed location will produce unsafe conditions, an official objection to the location is to be made within the 5 days and the period for issuing a license is to be extended to 10 days. Within this 10 days the interested parties are to confer. It was the intent that so far as possible the well inspector should decide on locations, and that the well operator could depend on the issuance of a license to drill within the 10 days. However, in cases where a well inspector should be unable to decide, his refusal to issue a license at the end of 10 days would allow the whole matter to be brought before the proper court of the county.

RESURVEY.[b]

The requirement of a resurvey in the case of an unsatisfactory original location is to assure correct records. This requirement would also tend to bring about a well-considered original location in order to avoid the expense of resurvey.

MINE PLATS.[c]

The coal operator is required to furnish to the well inspector the same plats of his mining operations as are usually required to be furnished to the State mine department, in order that the well inspector may know whether a proposed well location is in the immediate neighborhood of mining operations. The well inspector will in time be able to delimit those areas in which coal-mining interests and well drilling do not coincide, and thus quickly issue licenses to drill in most territory.

DISTANCE OF WELL FROM BUILDINGS.[d]

In order that gas may not be drawn into the ventilating system of any mine, a minimum distance from mine openings has been provided, and a similar minimum distance to those buildings that are

[a] Art. II, sec. 6. [b] Art. II, sec. 7. [c] Art. II, sec. 8. [d] Art. II, sec. 9.

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vital to the safety of operation of a mine, so that in case of fire at either wells or mine buildings the risk shall not be increased. If this limitation were imposed for every opening into a coal seam it would be possible, where small country banks are worked, very greatly to restrict the possible drilling area, and for that reason this section was made to apply to coal mines of sufficient size to be artificially ventilated.

DISTANCE OF WELL FROM MINE WAYS.[a]

It seems evident that a bore hole should not go through any underground haulage way, traveling way, drainage way, or airway, and in order to insure against errors in surveying and location the limitation of 15 feet from such ways was imposed. This section was the subject of much discussion and it was the general belief that such a bore hole should go through a rib or coal pillar, and that the existence of these several ways implied ribs or pillars of sufficient stability to maintain the mine passageways and, therefore, to protect the ground about the well. Objections were made to implying that if a well were put in solid coal not closer than 15 feet to a way such a location would be safe and permissible. The general opinion was that if the entry pillars were of normal proportions such a location would be safe and permissible, but in special or unusual conditions the inspector may refuse to issue a license to drill, and the matter would then be taken into court where the testimony of mining men, and geologists and other technical and practical evidence could be presented.

EXPIRATION OF LICENSE.[b]

A well may be located in an acceptable place and a license to drill may have been issued, but if the drilling of the well is postponed for a long period the location may become unacceptable.

MANNER OF DRILLING AND PROTECTING WELL.[c]

GENERAL CONSIDERATIONS.

There are two main protections against the possible leakage of gas into a coal mine from a well boring—first, the lack of gas pressure within the casing; and, second, the integrity of the casing itself. To be assured of a lack of pressure within the casing a vent at the top is provided of such a character that it can not be readily closed. In the case of leakage of gas into this casing space, although there is a free vent at the top of the casing, yet gas may be drawn into the mine, provided the casing itself is not intact. This could occur in many ventilating systems where the absolute pressure within the mine due to the suction of the fan is less than the absolute pressure of

[a] Art. II, sec. 10. [b] Art. II, sec. 12. [c] Art. III.

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the atmosphere at the top of the casing. For a safe condition, therefore, dependence must be placed on the integrity of the casing. The casing may be injured by deformation due to movement of the ground, fall of roof, or accident within the mine. It is believed that if the casing is held within an enlarged hole and the space between the hole and the casing filled with a yielding material, such as clay, the danger from rupture is somewhat reduced. Experience with clay for this purpose is, however, so limited, and the use of cement mortar is so much more common, that either material is allowed for this purpose. There is very little evidence on the subject of rupture of casing due to movement of the ground or the fall of roof. Such a danger to casing is certainly remote, as shown by the past experience of well drillers. The deformation that such casing can stand before actual rupture is indicated by the results of the following test, which is reported as having been tried in the Louisiana field.

Two pieces of 8-inch casing, screwed into the usual coupling, were placed on supports 20 feet apart, with the coupling midway between the supports. A force was applied at the coupling to bend the combination, when a deformation of 3 to 5 feet was possible before the tightness of the casing was destroyed. In another case, a casing through a haulage way was struck by mine cars in such a way as to bend the casing some 5 inches out of line and to flatten the side that was struck so that it was 12 inches out of line without any leaks opening in the casing.

However, more evidence on the subject of rupture of casings by ground movement is needed.

If the space within the casing contain gas and the casing be corroded through, then there may be a leak of gas into the mine through such corroded openings. It appears, therefore, that ultimate protection depends on the resistance to corrosion of the casing, and it must be required that this protection be reasonable and efficient. It is evident that the larger the amount of metal interposed between the corroding water and the inside of the casing the longer will be the life of the casing. The corrosive action of acid mine water may, however, be so relatively rapid on metallic parts that the real protective feature must be something other than thickness of metal. Both puddled-clay and cement covering is proposed for this protection against corrosion. Cement has the advantage of stability of form and ease of application, but will crack with a slight movement and is itself affected by acids. If there be any lateral movement of the ground, the rigid cement casing is apt to be broken and allow corrosive waters to attack the metal casing. Puddled clay has the advantage of some plasticity in case of movement of the ground; but unless the clay be carefully supported, it lacks the stability of cement in that it may be washed out by water.

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In the development of protective methods for casings going through a mine opening or coal bed, it is a question just how far the well operator should be required to go. It is manifest that further protection against corrosion can be had by requiring larger holes and added metallic casings and more layers of clay or cement, but such

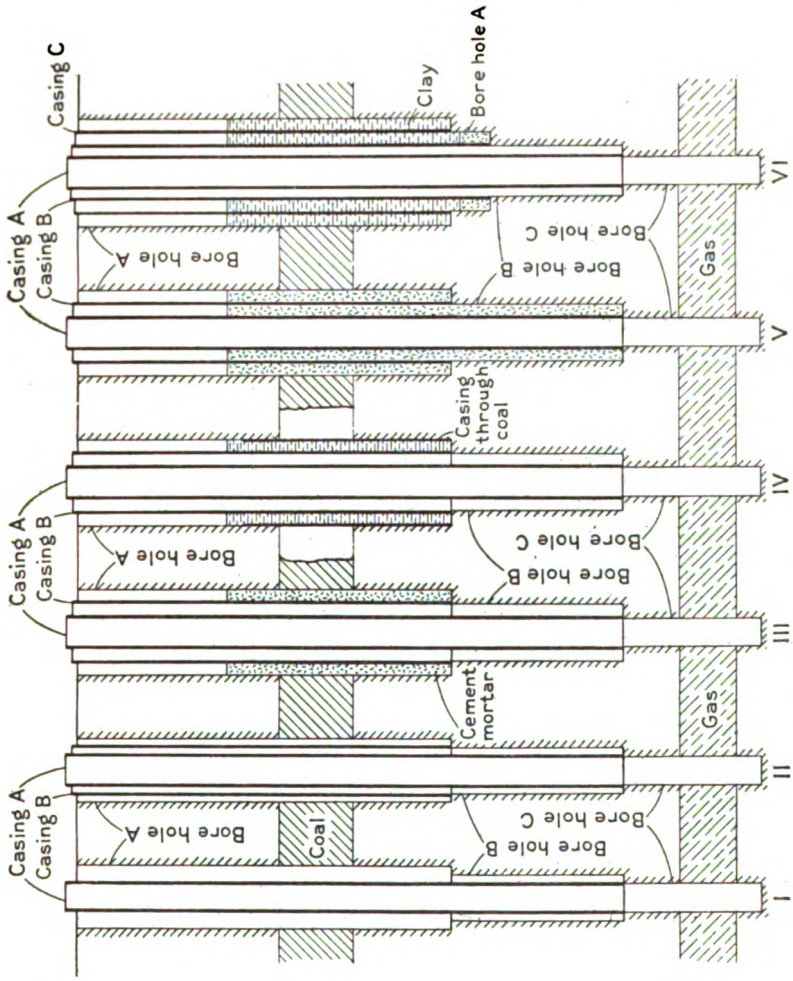

FIGURE 1.—Six methods of casing and protecting bore holes.

added protection may entail unreasonable expense on the well operator without a corresponding increase of protection.

DISCUSSION OF CASINGS SHOWN IN FIGURE 1.

Figure 1 shows six methods of casing and protecting wells. From left to right in the figure the methods indicated increase in complexity, cost, and effectiveness.

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CASING SHOWN IN I.

The casing shown in I of the figure represents one string of casing (A) closed at top and extending downward to a hard formation above the principal producing sands. In current practice such a casing is carried down to shut off caving material and may pass through several producing sands of minor importance.

Advantages.—Retains the wall from caving and thus plugging the hole and permits the replacing of tubing whenever necessary.

Casing can yield laterally somewhat and accommodate itself to distortion.

All the casing can be recovered.

Cheapest possible form.

Disadvantages.—Allows gas and water to enter the coal seam from upper measures, or permits leakage.

Allows water to enter the upper gas and oil sands.

Allows intermingling and pollution of waters, springs, and wells.

Is subject to corrosion and is without protection.

CASING SHOWN IN II.

The casing shown in II (fig. 1) represents a type used in current practice, involving two strings of casing (A and B), the first extending to a hard formation above the first producing sand, the second extending to a point below all caving material.

Advantages.—Retains wall from caving.

Shuts out gas and oil from coal seams.

Shuts out water from oil and gas sands.

Allows a vent to the atmosphere to dissipate leaking gas.

All casing can be recovered.

Prevents free intermingling and pollution of waters.

Can yield and accommodate itself to distortion.

Disadvantages.—Both casings may be corroded by acid mine water.

If the casing is disturbed by movement of overlying strata the joint at the seat may be broken and gas may escape into the mine.

If the casing is corroded and air pressure in the mine is less than at the top of the casing the vent is ineffective.

CASING SHOWN IN III.

The casing shown in III (fig. 1) represents a casing passing through a coal bed in which the coal is in place. Two strings of casing are included. If the outer or first string (B) is set in cement mortar, this type of casing offers the following advantages and disadvantages:

Advantages.—Retains wall from caving.

Shuts out gas, oil, and water from coal seam.

Shuts out water from oil and gas sands.

Allows vent to atmosphere.

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Retards corrosion.

Prevents free intermingling and pollution of waters.

Disadvantages.—Cement holds the casing rigid, and as yielding by bending is impossible the casing may be broken and the coal bed exposed to gas.

All casing can not be recovered.

Protection against corrosion incomplete if cement cracks.

If the outer or first string (B) be set in puddled clay, the advantages and disadvantages of this type of casing are as follows:

Advantages.—Retains wall from caving.

Shuts out gas, oil, and water from coal seam.

Shuts out water from oil and gas sands.

Allows vent to atmosphere.

Retards corrosion.

Prevents free intermingling and pollution of waters.

Casing can be recovered.

Packs against oil or gas leaks.

Allows casing to yield to bending pressure.

Disadvantages.—Clay may not remain in position if coal is later removed.

CASING SHOWN IN IV.

The casing shown in IV (fig. 1) represents a casing passing through a mine opening. Two strings of casing are included. If the outer or first string (B) is set in cement contained in a liner, this type of casing offers the following advantages and disadvantages:

Advantages.—Retains wall from caving.

Shuts out gas, oil, and water from coal mine.

Shuts out water from oil and gas sands.

Allows vent to atmosphere.

Retards corrosion.

Prevents free intermingling and pollution of waters.

Disadvantages.—Cement holds casing rigid, and as yielding by bending is impossible, the casing may be broken and the coal mine exposed to gas.

Casing can not be recovered.

Protection against corrosion incomplete if cement cracks.

If the outer or first string (B) be set in puddled clay contained in a liner, the advantages and disadvantages of this type of casing are as follows:

Advantages.—Retains wall from caving.

Shuts out gas, oil, and water from coal mine.

Shuts out water from oil and gas sands.

Allows vent to atmosphere.

Retards corrosion.

Allows casing to yield to bending pressure.

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Packs against gas or oil leaks.

Casing may be recovered.

Prevents free intermingling and pollution of waters.

Disadvantages.—Liner may be corroded and in a strong current of acid mine water the clay may be washed away and casing subjected to corrosion.

CASING SHOWN IN V.

The casing shown in V (fig. 1) represents a protected casing, consisting of two strings, both of which are set in cement.

Advantages.—Retains wall from caving.

Shuts out gas, oil, and water from coal seam.

Shuts out water from oil and gas sands.

Double thickness of cement and iron to protect against corrosion.

Prevents intermingling and pollution of waters.

Disadvantages.—Casing is held rigid, and as yielding by bending is impossible, the casing may be broken and the coal seam or mine exposed to gas.

Vent to atmosphere is closed and gas may build up pressure and be forced into the coal seam through faults and crevices.

Casing can not be recovered.

If laterally displaced, cement cracks and exposes casing to corrosion.

CASING SHOWN IN VI.

The casing shown in VI (fig. 1) represents a protected casing, consisting of three strings. The first (C) is set in clay, the second (B) is seated in cement and surrounded by clay.

Advantages.—Retains wall from caving.

Shuts out gas, oil, and water from coal seam.

Shuts out water from oil and gas sands.

Allows casing to yield to bending pressure and preserves a vent to atmosphere.

Packs tight against gas leaks, even if distorted.

All casing can be recovered.

Prevents intermingling and pollution of waters.

Double thickness of cement and iron to protect against corrosion.

Disadvantages.—Requires an extra large hole to a point below the coal and an extra string of large casing.

This will add materially to the cost.

TYPE OF CASING RECOMMENDED.

The type of casing shown in III and IV of figure 1 is the type recommended in the conference report.

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CONSIDERATIONS INFLUENCING PRESCRIBED DIMENSIONS.[a]

The difference in diameters prescribed for bore holes and casings, depending on the location of the bore holes, provides a protective covering for the metallic casing of approximately 2 inches in thickness outside of couplings and about $2\frac{3}{4}$ inches for the body of the casing. The casing was required to be put 30 feet below the bottom of the coal bed in order to insure the rigid holding of the casing by firm ground. The cement was required to be run 30 feet above the coal bed in order to get it above the effects of the usual caving of the roof and to exclude water in the event of a cave.

AFFIDAVIT AS TO CASING.[b]

In order that there shall be no misunderstanding as to the manner in which the well operator complies with the law in the matter of a casing through a coal bed, it is required that an affidavit be made as to the type of such casing, the affidavit to be filed immediately upon the completion of the work of casing through the coal bed, while the matter is fresh in mind and within the possible knowledge of the coal operator.

VENT.[c]

One of the essential means of protection is the existence of a vent to the outer atmosphere from within the outer casing. The lack of such a vent is generally admitted to be the most serious cause of such damage as has heretofore occurred from the leakage of gas from active gas wells into mines. It does not seem to be sufficient to provide an opening that may be readily closed with a valve or plug. The ventilating opening should, therefore, be of such design that it can not be readily closed. The practice of one company is to end the vent opening with a perforated pipe with a plugged end.

ABANDONMENT OF WELL.[d]

NOTICE.[e]

The opinion was general in the conference that a notice of intention to abandon a well should be filed with the chief well inspector, and that, so far as possible, the plugging of wells should be done under inspection.

PROCEDURE IN ABSENCE OF INSPECTOR.[f]

It was considered that inspection should be prompt, or else that provision should be made to allow the well operator to continue his work without delay.

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[a] Art. III, sec. 1.
[b] Art. III, sec. 2.
[c] Art. III, sec. 3.
[d] Art. IV.
[e] Art. IV, sec. 1.
[f] Art. IV, sec. 2.

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LOCATING OLD WELLS.[a]

The conference considered that it was desirable that all old wells should be accurately located, but the impracticability of this was evident. In order that as many old wells as possible may be so located, section 4 of Article IV requires that any well drilled prior to the passage of the regulations shall, upon abandonment, be properly described and located.

METHOD OF PLUGGING.[b]

Two principles are involved in the method of plugging—first, the passage of oil, gas, or water from one strata to another must be prevented; second, any spaces or pockets that may contain gas under pressure and that might find sudden relief should be eliminated.

METHODS OF PLUGGING SHOWN IN FIGURE 2.

Figure 2 shows six methods of plugging wells. From left to right in the figure the methods indicated increase in effectiveness.

PLUGGING SHOWN IN I.

The plugging shown in I (fig. 2) is typical of that frequently used under existing laws.

Advantages.—Shuts out water from gas sand.

Disadvantages.—Allows the free intermingling of waters from different strata, causing the pollution of waters, springs, and wells.

The hole can not be maintained open to atmosphere. The top will cave and plug the hole above the coal bed.

Allows pocket for storage of gas under pressure.

Gas may escape into the hole and remain a menace to mine operations.

This plug can not be set against a heavy gas (or rock) pressure.

PLUGGING SHOWN IN II.

The type of plugging represented in II (fig. 2) offers the following advantages and disadvantages:

Advantages.—Shuts out water from coal beds.

Shuts out gas from coal beds.

Disadvantages.—Allows pocket for storage of gas under pressure.

Allows gas to enter formation below coal bed.

Allows the free intermingling of waters from different strata.

Can not be used in case of heavy gas pressure.

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[a] Art. IV, sec. 4. [b] Art. IV, sec. 5.

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PLUGGING SHOWN IN III.

The type of plugging shown in III (fig. 2) represents a combination of the types shown in I and II.

Advantages.—Shuts out water from coal bed.

Shuts out gas from coal bed.

Shuts out water from gas sand.

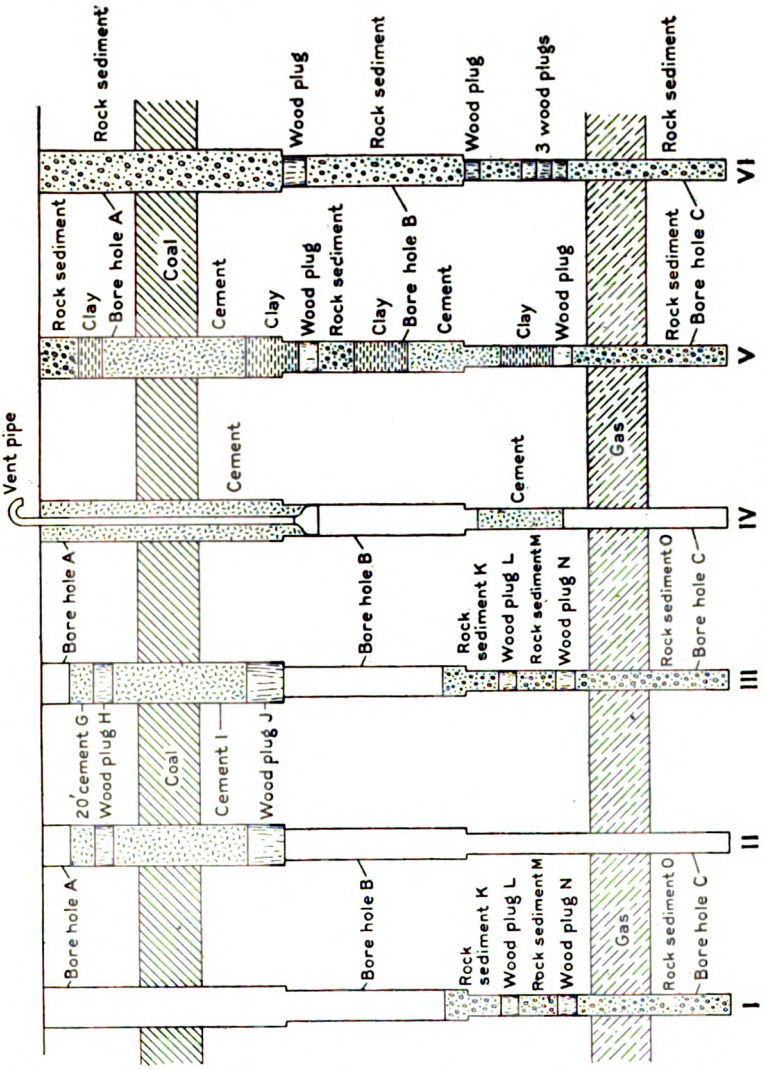

FIGURE 2.—Six methods of plugging wells.

Disadvantages.—Allows pocket for storage of gas under pressure.

Allows the free intermingling of waters from different strata.

Gas may pass lower plug and escape into the formation below the coal bed.

This plug can not be set against a heavy gas pressure.

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PLUGGING SHOWN IN IV.

The type of plugging shown in IV (fig. 2) provides for a vent in that part of the plug that passes through the coal.

Advantages.—Shuts out water from coal bed.

Shuts out gas from coal bed.

Shuts out water from gas sand.

Disadvantages.—Allows pocket for storage of gas under pressure.

Allows intermingling of waters from different strata.

Allows intermingling of oil and gas from different strata.

Vent pipe may easily be broken or corroded if cement is broken, especially through inaccessible mine opening.

Plugging against gas pressure difficult.

Safety absolutely dependent on integrity of vent pipe.

PLUGGING SHOWN IN V.

The method of plugging shown in V (fig. 2) comprises a composite clay and cement plug.

Advantages.—Allows no pocket for storage of gas under pressure.

Shuts out gas, oil, and water from the coal bed.

Prevents intermingling of gas and oil.

Prevents intermingling and pollution of water.

Disadvantages.—Is expensive.

Requires cleaning hole of oil where cement is placed, or makes likely poor cement in an oily hole.

PLUGGING SHOWN IN VI.

The type of plugging shown in VI (fig. 2) embodies filling solidly as recommended by the conference.

Advantages.—Allows no pocket for storage of gas under pressure.

Shuts out gas, oil, and water from the coal bed.

Prevents intermingling of gas and oil.

Is tight enough to resist heavy pressures.

Disadvantages.—Is expensive.

DISCUSSION.

The tightness of the plugging shown in VI, figure 2, is dependent largely on the use of wooden plugs and clay. The wooden plugs are preferred to the cement and clay because of the uncertainty as to the quality of cement when put into oily holes. To prevent the possible accumulation of gas in pockets the entire space between wooden plugs is to be filled in such a manner as to leave the smallest possible percentage of voids. These plugs and materials should be properly placed, and it is required that they be driven into place by drilling tools. A question was raised as to the necessity of filling entirely the holes between the wooden plugs prescribed, as there would be

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some localities where there would be great difficulty in obtaining proper material for filling. The requirement was, however, considered as fundamental for good work. The entire filling of the hole meets many of the requirements of others than the coal operator in that water-bearing measures as well as all gas and oil sands are thus protected. The avoidance of pockets filled with gas is very necessary, as it is a matter of record that a relatively small quantity of gas drawn suddenly from an old well into a certain mine produced a serious loss of life by a resulting fire.

The mining interests were quite willing to forego more rigid requirements in other directions if they could feel assured that old holes were entirely and completely filled. It was pointed out that even if such plugging and filling should allow some gas to leak, the leakage would be at a relatively low rate, such that ventilation methods would care for it, whereas if there should be fear of an accumulated pocket of gas that might find sudden relief, the well would be considered a menace.

A well that is valueless for commercial purposes may produce gas slowly from deep-seated strata and at great pressure. If the bore hole is open for 1,000 or 2,000 feet between plugs, forming a large pocket, the gas may gradually accumulate at a pressure approximating the original rock pressure. If a 10-inch hole is open for 1,000 feet it would contain at 60 atmospheres a volume of gas that would expand to 33,000 cubic feet if suddenly released. Such a relief might be found through the strata into a mine, and, mixing with the air of the mine, the gas might form 600,000 cubic feet of explosive mixture. If this should be ignited, a disastrous explosion might result; hence the great desirability of filling all cavities in which gas might accumulate.

REPORT OF PLUGGING.[a]

The existence of either active or abandoned wells on a piece of property might be considered as an encumbrance on that property from the point of view of a coal operator. In order, therefore, that the true state of this encumbrance should be known at any time, not only is it necessary that there be a record of the location, and of the method of casing through coal measures, but also a complete record should be available of the abandonment and plugging of the well.

CHIEF INSPECTOR OF NATURAL-GAS AND PETROLEUM WELLS.[b]

It was the general opinion that it would be useless to enact laws without a special officer to carry them into effect. The method of appointment of this officer, whether by the governor of a State or by a commission variously constituted and provided for the purpose, or

[a] Art. IV, sec. 6. [b] Art. V.

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whether the office should be one in connection with existing offices in the State, or should be separate and independent, were all matters of general discussion, and brought out some difference of opinion. Some of the State coal-mine inspectors, as indicated by letters received from them, were of the opinion that this work should be under the jurisdiction of the State department of mines. It was the general belief of the conference, however, that inspectors for the supervision of natural-gas and petroleum wells required a different preparation than that required for the inspectors of coal mines, and that the inspection of mines and of wells should not be performed by the same persons. That it was possible to organize such a well-inspection department under the State department of mines, or that such a department might be a part of the geological survey in some States, was recognized.

PUBLICATIONS ON PETROLEUM TECHNOLOGY.

The following Bureau of Mines publications may be obtained free by applying to the Director, Bureau of Mines, Washington, D. C.:

BULLETIN 19. Physical and chemical properties of the petroleums of the San Joaquin Valley, Cal., by I. C. Allen and W. A. Jacobs, with a chapter on analyses of natural gas from the southern California oil fields, by G. A. Burrell. 1911. 60 pp., 2 pls., 10 figs.

BULLETIN 65. Oil and gas wells through workable coal beds; papers and discussions, by G. S. Rice, O. P. Hood, and others. 1913. 101 pp., 1 pl., 11 figs.

TECHNICAL PAPER 3. Specifications for the purchase of fuel oil for the Government, with directions for sampling oil and natural gas, by I. C. Allen. 1911. 13 pp.

TECHNICAL PAPER 10. Liquefied products from natural gas; their properties and uses, by I. C. Allen and G. A. Burrell. 1912. 23 pp.

TECHNICAL PAPER 25. Methods for the determination of water in petroleum and its products, by I. C. Allen and W. A. Jacobs. 1912. 13 pp., 2 figs.

TECHNICAL PAPER 26. Methods of determining the sulphur content of fuels, especially petroleum products, by I. C. Allen and I. W. Robertson. 1912. 13 pp., 1 fig.

TECHNICAL PAPER 32. The cementing process of excluding water from oil wells as practiced in California, by Ralph Arnold and V. R. Garfias. 1913. 12 pp., 1 fig.

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